

and right, though it may take millions of years to prove that right is right. I have the same faith in Nature; and, taking my stand on this scientific faith, I believe that natural selection must in the end prove rational selection, and that what has vaguely been called the survival of the fittest will have to be interpreted in the end as the triumph of reason, not as the mere play of chance.

F. MAX MÜLLER.

Oxford, February 21.

### "Coral Formations."

CAPTAIN WHARTON'S paper on coral formations in last week's *NATURE* (p. 393) will have been read with great interest by all who have examined and studied coral reefs. It is unlikely that any objections will be raised to the illustrations he has brought forward of how the coral plantations may be built up from deeply submerged banks, and eventually formed into complete atolls and barrier reefs at a great distance from continental and other shores. The mode of formation has been dwelt upon by Le Conte and Guppy in the case of barrier reefs, and I have pointed out the same thing in my remarks about the Maldivian and similar atoll groups. The instances cited by Captain Wharton are of great value, especially as he has been able to consult large manuscript plans.

Captain Wharton apparently considers that the solution of carbonate of lime by sea-water plays no important part in deepening, widening, and modifying the form of such atolls and barrier reefs; in this I cannot agree with him.

By reference to what is now taking place in Nature, as well as to experiments conducted in the laboratory, it has been shown that the solution of the carbonate of lime of dead shells and skeletons by the sea is as constant and universal as its secretion by the living organisms. From some considerations which I recently laid before the Royal Society of Edinburgh, it is probable that there is more secretion and deposition of carbonate of lime in the ocean, as a whole, than removal by solution, and it is almost certain that at the present time there is a vast accumulation of carbonate of lime going on within the coral-reef regions of the ocean. The amount of secretion becomes less with increasing depth beyond one hundred fathoms, and laboratory experiments under great pressures have shown that the rate of solution becomes greater with increasing depth; but both processes are always in action wherever there are life and growth, death and decay. In some regions secretion is in excess, and there is a formation of calcareous deposits; in others solution is equal to secretion, as over the red clay areas of the ocean. Again, solution may be in excess of secretion, as in the larger and more perfect coral lagoons. The rôle of carbonate of lime in the ocean may not inaptly be compared to that of aqueous vapour in the atmosphere over land surfaces. Where precipitation is in excess of evaporation, fresh-water lakes are formed, and rivers carry the surplus water down to the ocean; where evaporation is in excess, there is a formation of inland drainage areas, deserts, and salt lakes.

In small coral atolls the periphery is large relatively to the size of the lagoon, and the secretion of lime and formation of coral sand are greatly in excess of the solution that takes place, hence the lagoon becomes filled up; in it are frequently found deposits of sulphate of lime, guano, magnesian and phosphatic rocks. On the other hand, when a comparatively large atoll reaches the surface, the periphery being small relatively to the size of the lagoon, there is less secretion and formation of coral sand by the living outer surface than is removed in solution from the lagoon; it is in consequence widened, deepened, and reduced to a more or less uniform appearance, while the islands on such reefs never, so far as I know, contain deposits of sulphate of lime, guano, magnesian or phosphatic rocks. On open banks, such as the Macclesfield and Tizard Banks, the coral sand is generally largely made up of bottom-living Foraminifera, Polyzoa, Serpule, and Calcareous Algæ, and the bank may be rising from the secretions of these organisms; but when the peripheral reefs reach the surface the conditions become more or less inimical to vigorous growth, and in a perfect atoll the fine calcareous mud is removed at a relatively rapid rate.

My answer to Captain Wharton's question is that in all normal conditions the extent of surface in the shell, coral, or fragment of coral sand exposed to the action of sea-water compared with the mass determines the rate at which these organisms will disappear in solution. It is improbable that this action is extremely slow at the bottom of the deep lagoons. Independently of the

mixing by convection currents, even a very slight wind over the surface of the lagoon will set the whole water in motion. This is clearly shown by my observations in the western lochs of Scotland, which are much deeper than any lagoon; a moderate breeze produces motion at a depth of sixty fathoms in a very short space of time. The water mixed up with the mud at the bottom is thus changed long before the point of saturation is reached.

I have never seen any wide extent of fringing reef but what was very deeply cut up with channels, and from Captain Wharton's own description this appears to be the case at Rodriguez. That a ship channel has not there been formed is probably due to the shallow water surrounding the island and the probably rapid growth outward of the reef; the average depth outside the reef is usually less than ten fathoms, and at a distance of two miles seaward it is only from twenty to thirty fathoms. In some instances the large proportion of Calcareous Algæ on the reefs appears to compensate for the removal in solution, and thus to retard the formation of ship channels.

I doubt if any recent writer has attempted to give an "explanation which will fully account for the almost infinite variety of coral formations." It is unnecessary to state that each reef must have peculiarities depending on the nature and form of its foundation, and the meteorological and other conditions of the seas in which the reef is situated; it is only by a careful and detailed study of all these conditions that the peculiarities of any individual reef can be fully explained. At the same time it appears to me beyond doubt that the general and well-known characteristic features and form of coral reefs can be accounted for by reference to certain general considerations, chief among these being the vigorous growth of reef-forming species in positions and at depths where the supply of pelagic oceanic organisms, which form their food, are most abundant, and the removal of dead coral and coral debris wherever this is exposed to the action of sea-water.

Captain Wharton calls attention to our imperfect knowledge of the coral groups of the Pacific, but he understates the case in saying "that the waters of the Fiji and the Society Islands are the only ones which can be said to be in any sense surveyed." Cook, Kotzebue, Duperry, Beechy, and Wilkes have given running surveys of many of the Paumotu, and we know something about the depths inside and outside of a good many of them. We know much about the islands containing guano. The French have made some excellent charts of the New Caledonia reefs, and the Americans have done the same for some of the Hawaiian Islands. Captain Wharton will acknowledge that we have a splendid survey of the Maldives, the most extensive group of atolls in the world; the islands marked with names in this British Survey number 602. Other groups in the Indian Ocean are well surveyed, and nearly all the Atlantic reefs have been correctly laid down on charts.

I feel sure that all who take an interest in this subject will hope for many more contributions from Captain Wharton's pen on coral formations.

JOHN MURRAY.

I HAVE read with great interest the article on coral formations in your last number (p. 393), by Capt. Wharton. It is not because I wish to claim to have anticipated the views which he gives as to the formation of atoll lagoons and barrier reef lagoons that I am writing to state that at the very date of the publication of Capt. Wharton's article I was engaged in writing a paper on coral formations, based upon a study of living corals at Diego Garcia, and on a consideration of the great submerged atolls known as the Great Chagos Bank and the Pitt and Centurion Banks, situated north and west of that island, in which I arrive at conclusions nearly identical with his. It has seemed to me, as it has to him, that the solution of dead coral rock in the interior of a reef does not sufficiently account for the formation of lagoons, and that the true cause of the atoll and barrier lagoons surrounded either by a reef which is awash, or by a strip of low land, lies in the peculiarly favourable conditions for coral growth present on the steep external slopes of the reef. In Diego Garcia I observed that although the shore reefs are for the most part covered with 1 or 2 feet of water, even at the lowest spring tides, yet their flat surfaces are nearly invariably barren of growing coral. Just at their edges, however, and on the steep external slopes beyond the edges, reef-building corals grow luxuriantly. According to Capt. Moresby, quoted by Mr. Darwin in his book on "Coral Reefs," the flat surface of the rim of the Great Chagos Bank is barren of living corals,

just as are the shore reefs of the neighbouring atoll of Diego Garcia; but the lagoon contains many knolls abundantly covered with living coral, and there is reason to think that living coral also occurs on the external slopes at Diego Garcia. Unlike Capt. Wharton, I do not consider the favourable conditions for coral growth on the external slopes to be connected with a better food supply, for this would be at variance with the existence of thriving coral patches within the lagoon, which, as I have seen at Diego Garcia, bear no relation to the lagoon mouths, through which food-bearing currents might be supposed to enter to the interior. Indeed, at the last-named atoll some of the most luxuriant coral patches are found at the south end of the lagoon, furthest away from the lagoon outlet. The favourable conditions are due, I believe, to the action of currents on coral growth. I noticed at Diego Garcia, and Dr. Hickson has made similar observations in the reefs near North Celebes, that corals do not thrive where they are subjected to the direct action of a strong current, nor do they grow in still water, where they are killed by the sand deposited upon them, but they flourish in places where a moderate current flows over them, not so strong as to dash them to pieces, but strong enough to prevent deposition of sand. Such conditions are found everywhere on the external slopes. At the side where a current impinges directly on a slope, the deeper parts of the current strike the slope first, and are in part thrown upwards over the sloping surface, thus moderating the direct force of the more superficial part of the same current. The main part of the current flows tangentially around the obstruction, and thus affords favourable conditions at the sides of the atoll or reef, and finally, on the side furthest from the current, the back-wash causes weak superficial currents which are also highly favourable to coral growth. Thus the coral grows to the greatest advantage around the periphery of a reef, and, as Capt. Wharton says, a ring-shaped reef is the result, and no theory of solution is required to explain the central depression.

Capt. Wharton states that live coral exists in abundance on the rim of the Tizard Reef. It is not clear whether this means on the external slopes and on the extreme edge of the reef, or on the flat upper surfaces of the reef itself. From what I have observed at Diego Garcia, it appears to me hardly probable that the latter can be the case. Coral debris, torn from the corals growing on the slopes, is always carried across those flat surfaces in such quantity as to destroy any living corals upon them. In some cases corals may grow there, but then there are other favourable conditions neutralizing the effect of the debris. I am hoping soon to publish a full account of my observations at Diego Garcia.

G. C. BOURNE.

Anatomical Department, Oxford, February 28.

### Natural Science and the Woolwich Examinations.

IN accordance with Mr. Irving's recommendation, I have carefully considered the letter in the *Times* from the head master of Clifton College; but, with all due respect to his distinguished position, I find myself unable to accept his conclusions. Men of science will pardon me, if I ask them to examine facts, rather than to follow blindly even the highest authority.

The obligatory mathematics to be required from candidates for Woolwich are defined as follows in the official regulations, dated December 1887:—

"Algebra up to and including the binomial theorem; the theory and use of logarithms; Euclid, Books i. to iv. and vi.; plane trigonometry up to and including the solution triangles; mensuration; statics—the equilibrium of forces acting in one plane and of parallel forces, the centre of gravity, the mechanical powers; dynamics—uniform, uniformly accelerated, and uniform circular motion, falling bodies and projectiles *in vacuo*. (Analytical methods of solution will not be required.)

"N.B.—A thorough knowledge of each of the above branches of mathematics will be required."

This amount of mathematics is not beyond the reach of a fairly intelligent lad of seventeen who has been properly taught.

The inductive process which leads Mr. Irving to denounce so severely my supposed inappreciation of the value of experimental demonstration, laboratory training, and field work is hardly worthy of so eminent a teacher. Although there are good grounds for my opinion that chemistry, physics, and geology, are not good educational subjects for ordinary lads under sixteen, I am entirely consistent in the expression of my regret that the

War Office should have thought it desirable to discourage these sciences. Your able article conclusively proves that these subjects cannot be hastily and superficially learned in such a way as to gain unmerited marks. There are youths with apt intelligences, quick eyes, and skilful fingers, who ought to be allowed the advantage of their scientific capacity in the Woolwich competition. But I am unable to see that Mr. Irving's suggestion would do justice to these. A candidate who offered optional mathematics, one language, and two sciences, would be placed at a great disadvantage with those offering optional mathematics, and three languages, both on account of the lower maximum, and also because, with the same relative proficiency, it is so much harder to score in mathematics and experimental sciences and geology than in languages. I therefore respectfully submit that all who have the interests of science at heart should urge that the maximum should be raised to 3000 marks, but I do not think it would be desirable to allow candidates to take more than one subject from Class II., as it would tend to the neglect of more important studies.

2 Powis Square.

HENRY PALIN GURNEY.

### International Tables.

I AM instructed by the Meteorological Council to request your insertion of the following notice:—

The International Meteorological Congress, which met at Rome in 1879, recommended that a series of international tables should be prepared and issued.

The work was ultimately intrusted to a Sub-Committee, consisting of Prof. Wild and Prof. Mascart.

The Sub-Committee has prepared a scheme of tables, which has met with a general acceptance among the heads of European meteorological organizations.

The tables will be in royal quarto, and will cover about 400 pages. The price of the work, to be published by Gauthier-Villars, will be 35 francs.

The Council are requested by the gentlemen who have prepared the tables to ascertain the probable demand for the work in this country, and I am therefore to request through your columns that any intending purchaser will send his name to me.

ROBERT H. SCOTT.

Meteorological Office, 116 Victoria Street, London, S.W.,  
February 16.

### PLAN OF TABLES.

#### CHAPTER I.

##### Section I. Length.

|                            |                  |     |                |
|----------------------------|------------------|-----|----------------|
| 1. French lines            | to mm.           | ... | 0-100 lines    |
| 2. " "                     | " English inches | ... | " "            |
| 3. French inches and lines | " mm.            | ... | 20-30 inches   |
| 4. French lines            | " English inches | ... | 250-350 lines  |
| 5. English inches          | " mm.            | ... | 0-100 inches   |
| 6. " "                     | " "              | ... | 17-32 "        |
| 7. mm.                     | " English inches | ... | (in '001 inch) |
| 8. " "                     | " "              | ... | 0-100 mm.      |
| 9. Russian half-lines      | " mm.            | ... | 410-500 "      |
| 10. " "                    | " English inches | ... | " "            |
| 11. French feet            | " metres         | ... | " "            |
| 12. " "                    | " English feet   | ... | " "            |
| 13. English feet           | " metres         | ... | " "            |
| 14. Metres                 | " English feet   | ... | " "            |
| 15. Kilometres             | " English miles  | ... | " "            |
| 16. English miles          | " kilometres     | ... | " "            |

##### Section II. Weight.

|            |            |
|------------|------------|
| 1. Grains  | to grammes |
| 2. Grammes | " grains   |

##### Section III. Time and Angular Measure.

|                       |                                   |
|-----------------------|-----------------------------------|
| 1. Days of year       | to decimals of year and to angles |
| 2. Hours              | " "                               |
| 3. Minutes            | " "                               |
| 4. Hours              | " decimals of day "               |
| 5. Minutes            | " "                               |
| 6. Seconds            | " "                               |
| 7. Minutes or seconds | " decimal of the hour or minute   |
| 8. Seconds            | " decimals of hour                |
| 9. Longitude          | " time                            |
| 10. Time              | " longitude                       |

#### CHAPTER II.—GEODETICAL.

1. Variation of gravity with latitude and altitude.
2. Degrees on the meridian.
3. " on circles of latitude.
4. Duration of sunshine.